Snake Anatomy and Physiology

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Sense organs

The sense organs of snakes are uniquely different than those of mammals and other animals. Unlike mammals, which mainly rely on their sight and hearing, snakes rely primarily on their senses of smell and touch. They do not have moveable eyelids, but transparent caps called "brille" as protective eye coverings. Because of this, their eye movement is fairly limited. They also do not have an external ear, middle ear, or tympanic membrane (eardrum). Instead, they use a small ossicle (ear bone), called the "columella," to detect vibrations of sound waves conducted through the ground. They are able to pick up some sound waves conducted through the air, but only at very low frequencies.

Snakes also smell in a very different way than mammals. Mammals bring air particles into contact with the olfactory (smelling) nerves by breathing them into the nasal cavities through the nostrils. Snakes have both nostrils and nasal cavities, but they are not used to smell. Instead, the flicking tongue is actually a smelling device. There is a small organ on the roof of the oral cavity called the "vomeronasal organ", or "Jacobson's organ." The forked tongue is used to bring minute air particles into contact with this organ, and the snake then perceives and identifies the smell as prey, predator, or otherwise. So, unlike mammals, the tongue is not used to taste or aid in swallowing, but simply as an accessory smelling organ.

Some snakes also have a "sixth sense" that mammals and even other reptiles cannot boast. Vipers, rattlesnakes, and other members of the family of snakes known as the 'pit vipers' have special pits located between their eyes and nostrils. The pits are used to sense minute temperature changes as infrared rays, as an aid in locating warm-blooded prey such as rodents. A pit has two chambers. The interior chamber is naturally the internal temperature of the snake itself. The exterior chamber heats up when it is close to a heat source, and the snake is then able to detect the temperature difference between the two chambers. This system is so accurate that pit vipers are actually able to detect temperature changes as little as 0.002° Celsius.

Skin

Snakes, like all reptiles, are covered in scales that protect them from abrasion or dehydration. The scales on the top and sides of the snake are smaller and thinner than those found on the belly side. The thick, large scales on the belly are called "scutes," and they help to protect and support the tissues that are in contact with the ground. The scales can be very colorful and organized into interesting patterns. Unlike most other animals, there is no way to tell a male from a female based on color, as they will almost always look the same externally.

Though snakes are often described as being "slimy," their skin is actually very dry, In fact, they only have two skin glands €“ a pair of anal scent glands that secrete a substance used to attract a mate, provide protection from predators, and mark territory. Unlike other animals, snakes continue to grow until the day they die. Consequently, snakes periodically shed their skin in a process called "ecdysis." Before shedding the skin, the snake takes on a slightly bluish hue and the eyes appear cloudy. This is caused by fluid located between the layers of skin. Mites, malnutrition, and trauma, among other things, may cause dysecdysis, or abnormal shedding.

The skin is normally shed all in one piece, including the brille. The exception is if the snake has a rattle. The rattle is retained as the snake grows, and a new segment is added each growth period. It is often falsely assumed that the number of rattle segments can indicate the age of the snake, like rings on a tree trunk. This is not accurate, because snakes often shed more than once a year. Young, rapidly growing snakes may even shed as much as once every two months. Also, as a rattlesnake ages, it may lose some of the end segments of the rattle. It is not therefore, accurate to judge the age of a snake by the number of segments of its rattle.

Muscles and locomotion

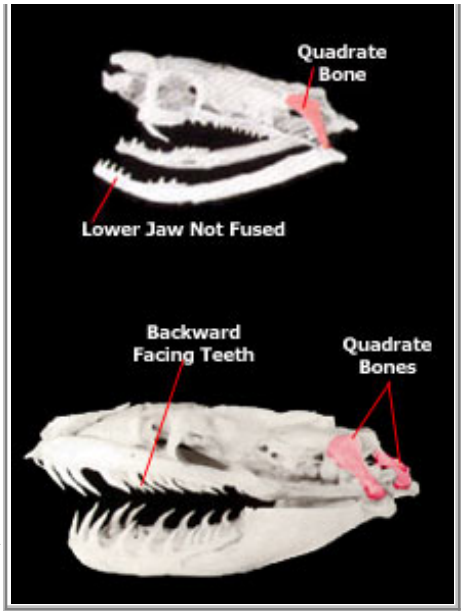
The muscles of the snake are utilized both to move ingested prey internally and for general body movement, or locomotion. There are four basic types of locomotion in snakes:

- Serpentine or lateral progression: This form of locomotion is the undulating crawl, commonly called 'slithering,' and the most common form of movement. It allows the snake to reach maximum speeds and is employed by all water snakes to swim.
- Rectilinear: Large, heavy snakes also use caterpillar or "inchworm" movement to travel in a straight line. They are able to move the skin of the belly forward and then pull the rest of the body along.
- Sidewinding: This locomotion is when snakes hurl their bodies in a sideways looping motion. Snakes that live in deserts on loose sand use this type of adaptive locomotion.
- Concertina: Some snakes apply the concertina technique when climbing trees. The body bunches up forming horizontal loops and then the head moves forward and the body straightens, similar to an accordion or spring.

Skeleton and teeth

Snake skeletons are not very complex because they do not have any

appendages (limbs). A few species, such as boas and pythons, retain some vestigial structures similar to pelvic bones. In some species, these can even be seen externally and are called "spurs." These structures are often used in reproduction. All other snakes simply have vertebrae, ribs, and a skull. Snakes can have between 130-500 vertebrae, with ribs attached to each one. This does not include the bones in the tail section, but only those that are forward of the cloaca (analogous to the anus in mammals).



A unique part of the snake skeleton is the makeup of the skull and teeth. Adaptations in the skull allow snakes to eat prey much larger than themselves. The bones are connected by elastic ligaments, allowing a lot of stretch. The joint of the upper and lower jaws is placed very posterior (far back) in the skull, allowing the mouth to open as wide as possible. Also, the bones of the lower jaw are not fused together at the front, which means, they can move apart when the snake is swallowing large prey. In addition, a snake has an additional loosely-attached bone called a "quadrate" on each side. This provides a "double hinge" at the joint and as a snake swallows, it alternately moves the jaws on each side of the face and "walks" the prey into its mouth. Another adaptation that helps the snake to swallow prey is the backwards curve of the teeth. They are angled toward the throat and act as hooks to prevent live prey from wiggling loose. Snake teeth are both acrodont (attached to the bone) and polyphydont (able to grow back when lost), and a snake may have several sets of teeth throughout its lifetime. This is necessary, because teeth are often lost while feeding. The type of teeth a snake has differs depending on the method used to capture and kill prey. There are three kinds teeth in snakea:

Constrictor dentition: Most snakes have two rows of teeth on each upper jaw and one row on each lower jaw. All of the teeth are short and hook-like. All non-poisonous snakes have constrictor dentition, regardless of whether or not they actually constrict their prey.

Poisonous snakes have either grooved fangs or hollow fangs.

Groove fanged: Fanged snakes have only one row of teeth on each upper jaw, plus a pair of fangs. The fang has a groove that serves as a path for the venom to flow into the prey from the venom glands located on the top of the head.

Hollow fangs: The teeth of the hollow-fanged snakes serve the same purpose as grooved fangs, but the fangs are more like a hypodermic needle through which the venom flows. These fangs can be either erectile or fixed. The erectile teeth are retracted into a groove on the roof of the mouth and extend when the mouth opens to strike, but fixed fangs are always extended.

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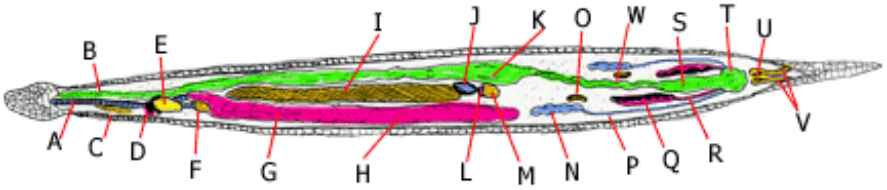
- Constrictor
- Groove fanged
- Hollow fanged

Respiratory system

Internal Ventral View of the Male Snake



A. Trachea
B. Esophagus
C. Thymus
D. Thyroid
E. Heart
F. Vestigial left
G. Right lung
H. Air sac
I. Liver
J. Gall Bladder
K. Stomach
L. Spleen
M. Pancreas
N. Testis (right)
O. Adrenal gland
P. Ductus deferens
Q. Kidney
S. Colon
T. Cloaca
U. Scent glands
V. Hemipenes
W. Small intestine

lung L. Spleen (right) intestine R. Ureter

The respiratory system of snakes includes the trachea (windpipe), bronchi, lungs, and air sac. The trachea originates at back of the oral cavity, and ends near the heart, where it branches into two bronchi. The left bronchus leads to the left lung, which is very small or completely vestigial. Vestigial organs are small, degenerate, and non-functioning. The right bronchus leads to the right lung, which is elongated. The forward portion of the lungs is vascular (with blood vessels) and functions in gas exchange, but the second half of the lung is an avascular (without blood vessels) air sac that extends into the tail region. The air sac performs a hydrostatic function in most snakes, regulating pressure inside the body cavity. Because snakes do not have a diaphragm, air enters and leaves the lung due to action of the body muscles and movement of the ribs.

Digestive system

The digestive system is composed of the esophagus, stomach, small intestine, colon, and glands. The esophagus runs adjacent to the air sac from the pharynx, or throat, to the stomach. In mammals, the esophagus is very muscular and moves food to the stomach. In the snake, however, the esophagus has very little muscle and food is moved to the stomach more by movement of the entire body. The junction between the esophagus and the stomach is not well defined, and the stomach itself is not very advanced. It is short and narrow with interior longitudinal folds to increase the surface area for digestion and absorption. The small intestine is likewise relatively simple. There may be a few loops or folds, but for the most part it is a long tube that receives food from the stomach, absorbs nutrients from it, and transports it to the colon, or large intestine. The colon then carries the fecal matter to the cloacal opening where it is disposed. The cloaca is a common chamber, receiving products from the digestive, urinary, and reproductive systems.

The liver, gall bladder, and pancreas are all associated with the digestive system. The liver is the largest internal organ in a snake, filling the space between the heart and stomach. One of the many functions of the liver is to produce bile, a digestive enzyme. The gall bladder and spleen are found near the posterior tip of the liver. The gall bladder stores bile produced by the liver and releases it into the small intestine when needed. The pancreas also secretes digestive enzymes into the small intestine, as well as producing hormones that regulate blood sugar.

Cardiovascular system

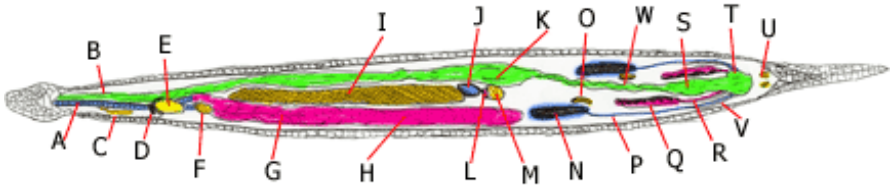
Two atria and one ventricle make up the three-chambered heart of a snake. The right and left atria receive blood from the lungs and body, respectively, and pass it to the ventricle to be circulated again. Encased in a sac, called the "pericardium," the heart is located at the branching of the bronchi. The heart is able to move around, however, due to the lack of a diaphragm. This adjustment protects the heart from potential damage when large ingested prey is passed through the esophagus. The spleen is attached to the gall bladder and pancreas and functions to filter the blood and recycle old red blood cells. The thymus gland is located in fatty tissue above the heart and is responsible for the maturation of special immune cells in the blood.

Endocrine system

The endocrine system is made up of glands that secrete hormones essential to normal body function. Snakes have the same endocrine glands as mammals. A few examples are the thyroid, parathyroid, and adrenal glands. The thyroid gland located in the throat area is responsible for proper growth and development, such as normal shedding of the skin. The parathyroid is a paired structure located near the thyroid and helps in the metabolism of calcium. The two adrenal glands are located in the tail region, suspended in a mesentery (membrane sheet attaching organs to the body wall) near the reproductive organs. They secrete the hormone epinephrine (adrenaline) that increases heart and respiratory rates when the animal is in a dangerous situation.

Genitourinary system

Internal Ventral View of the Female Snake



A. Trachea B. Esophagus C. Thymus D. Thyroid E. Heart F. Vestigial left lung	G. Right lung H. Air sac I. Liver J. Gall Bladder K. Stomach L. Spleen	M. Pancreas N. Ovary O. Adrenal gland P. Oviduct Q. Kidney (right) R. Ureter	S. Colon T. Cloaca U. Scent glands V. Uterus W. Small intestine

The kidneys are the organs responsible for urinary output. In the snake, the kidneys are elongated, and the right kidney is situated closer to the head than the left. These organs filter the blood and remove waste products, which are then concentrated and transported, via the ureters, to the cloaca. The ureters are hollow tubes for transporting urine. In mammals, the ureters empty into the urinary bladder where the urine is stored and later expelled through another tube called the "urethra." Because snakes do not have a urinary bladder, the urine is not stored, and the ureters empty directly in the cloaca.

The paired gonads, testes in the male and ovaries in the female, are situated in a similar fashion, with the right being closer to the head than the left. They are also located closer to the head than the kidneys. In the female, the ovaries are near the oviducts, which carry eggs to the uterus before they enter the cloaca. Some snakes are oviparous (egg-laying) and some are viviparous (having live birth). In mammals, males have two ducts associated with each teste €“ the epididymis and ductus deferens. Snakes lack epidiymides and the sperm are simply transported from the teste through the ductus deferens to the cloaca. The male also has organs called "hemipenes" that are located in back of the cloacal opening. The hemipenes are paired copulatory organs, and they are both fully functional, though only one at a time is used to transfer sperm to the female. The hemipenes are closely associated with the scent glands, or musk glands, which are also present in the female.